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TRANSAPICAL AORTIC OCCLUSION FOR CARDIOPLEGIC DELIVERY DURING RECONSTRUCTION OF THORACOABDOMINAL AORTIC ANEURYSM WITH DEEP HYPOTHERMIC CIRCULATORY ARREST

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The deep hypothermic circulatory arrest (DHCA) technique is currently used during reconstruction of the descending and thoracoabdominal aorta to prevent spinal cord injury. With this procedure, however, cardioplegic arrest for myocardial protection may not be obtainable through the left thoracotomy. Early reperfusion of the heart and brain after the completion of a proximal aortic anastomosis through the side branch of the graft may eliminate the ischemic cardiac and cerebral injury. However, prolonged cardiac fibrillation during the reconstruction of the intercostal arteries and visceral branches after the proximal anastomosis may deteriorate the myocardial function, especially in diseased heart cases. Recently, we developed a double-lumen balloon catheter that is inserted from the left ventricular apex for occlusion of the ascending aorta and cardioplegic delivery during the reconstruction of a thoracoabdominal aortic aneurysm through the left thoracotomy.

An operative technique. The aortic occlusion catheter (model 10F-60; Ideas for Medicine, Inc, St Petersburg, Fla) was devised for cardioplegic delivery through the left ventricular apex. The tip of the balloon catheter is occluded by glue, and a small side hole is located just beneath the balloon, enabling the cardioplegic solution in close proximity to the balloon to be flushed (Fig 1, *A*). The balloon can be inflated up to 48 mm in diameter with 50 mL of saline solution. The occlusion balloon can be inserted through the left ventricular apex, into the ascending aorta, guided by a transesophageal echocardiogram (Fig 1, *B*). This method had been applied in 2 cases. One patient, a 76-year-old man, had a thoracoabdominal aneurysm (Crawford classification; type III) complicated by an abdominal aortic dissection originating from the aneurysm. The other patient, a 67-year-old woman, had a chronic type III aortic dissection. She had undergone a previous operation to replace the proximal descending aorta. In both patients, the thoracoabdominal aorta was exposed by the extraperitoneal approach with a left thoracotomy through the seventh intercostal space, and cardiopulmonary bypass was initiated through the femorofemoral bypass. The left side of the heart was vented via the left inferior pulmonary vein. Once the heart had fibrillated, the occlusion balloon catheter was inserted through a purse-string suture on the left ventricular apex and introduced into the ascending aorta. After inflation of the balloon, which was monitored by transesophageal echocardiography to occlude the ascending aorta appropriately (Fig 2), cardioplegic solution was infused through the side hole just beneath the balloon and cardiac arrest was obtained. At a rectal temperature of 20°C, DHCA was instituted and a proximal anastomosis between the graft and the descending aorta was performed. After the completion of this anastomosis, the arch vessels were reperfused through the side branch of the graft, leaving the ascending aorta occluded by the balloon. Cardioplegic solution was infused every 30 minutes during the reconstruction of the intercostal arteries and visceral branches. After the reconstruction of the visceral branches, rewarming was started, and then the occlusion balloon was deflated and removed to reperfuse the heart. The distal anastomosis between the graft and the abdominal aorta was made, and the total bypass flow was restored through the side branch of the graft. Cardiopulmonary bypass was weaned easily without any cardiac events, and both patients recovered uneventfully.

Discussion. DHCA is a useful adjunct during an operation on the descending thoracic and thoracoabdominal aorta when severe aortic disease precludes the placement of clamps on the aorta.[1] Furthermore, hypothermia has a marked protective effect on the spinal cord and visceral organs during periods of aortic occlusion.[2] However, for patients who are undergoing DHCA through the left side of the chest, cardioplegic cardiac arrest under aortic crossclamping is not obtainable for technical and anatomic reasons. Although hypothermia also protects the myocardium, prolonged hypothermic fibrillatory arrest may impair the myocardial perfusion even if venting is performed, especially in the presence of a hypertrophied heart, aortic insufficiency, or coronary artery disease. The report by Kouchoukos and associates,[3] stating that the main causes of 5 deaths out of 51 patients who underwent operations on the descending thoracic and thoracoabdominal aorta with the DHCA technique were associated with postoperative myocardial dysfunction, arouses the need for myocardial protection during DHCA. Early rewarming after the reinstitution of cardiopulmonary bypass flow to the head and heart, which may induce the defibrillation of the heart, is an alternative method to protect the myocardium during the reconstruction of the thoracoabdominal aorta. However, the ischemic spinal cord or visceral organs may have the deleterious effects by rewarming. Okita and associates[4] developed the internal aortic occlusion method to infuse the cardioplegic solution dur-

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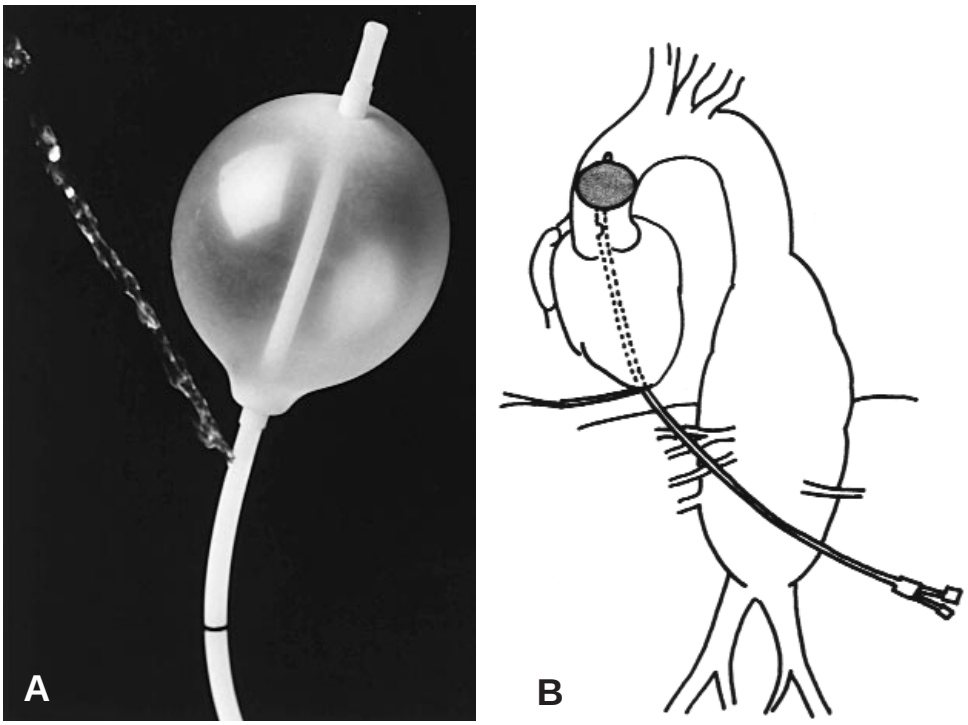

Fig 1. A, A flush of cardioplegic solution beneath the inflated balloon. **B**, Transapical aortic occlusion during reconstruction of thoracoabdominal aortic aneurysm with DHCA.

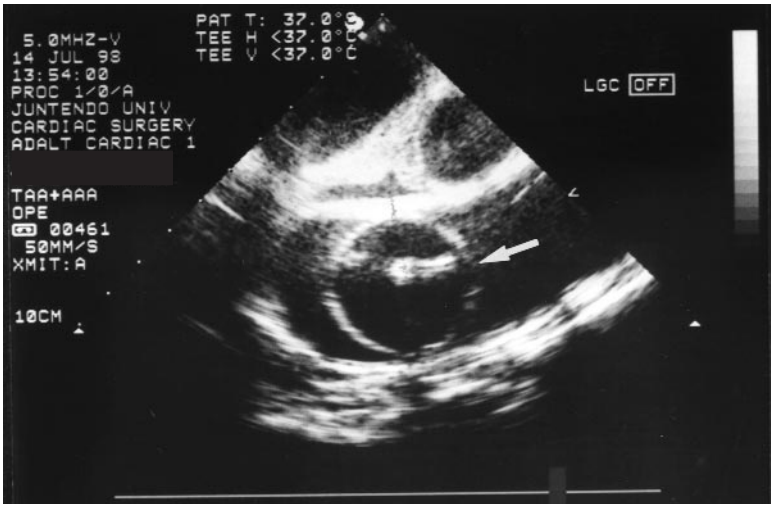

Fig 2. Transesophageal echocardiography during aortic occlusion. Inflated balloon in the ascending aorta (*arrow*).

ing the distal aortic arch reconstruction using a triple-lumen balloon catheter that is inserted from the cut end of the aortic arch. However, this method is applicable only for a distal aortic arch aneurysm and is not available for distal descending or thoracoabdominal aortic disease, because it may be difficult to introduce this balloon catheter into the ascending aorta far from the distal descending aorta. Furthermore, after the completion of the proximal anastomosis of the distal aortic arch, the balloon catheter that is inserted through the graft needs to be removed, with the result that prolonged cardiac fibrillation may be induced during the reconstruction of the intercostal arteries or visceral branches. Our newly developed double-lumen occlusion catheter can be introduced easily into the ascending aorta through the left ventricular apex. It protects

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the heart by infusing the cardioplegic solution under aortic occlusion by means of the balloon throughout the procedure. Even though the balloon catheter passes through the aortic valve, significant aortic valve insufficiency is not likely to occur because of the small caliber of the balloon catheter. We believe that the clinical application of this double-lumen aortic occlusion catheter will protect the myocardium in patients with a thoracoabdominal aortic aneurysm or distal descending aortic aneurysm who undergo the operation through the left thoracotomy with DHCA.

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